

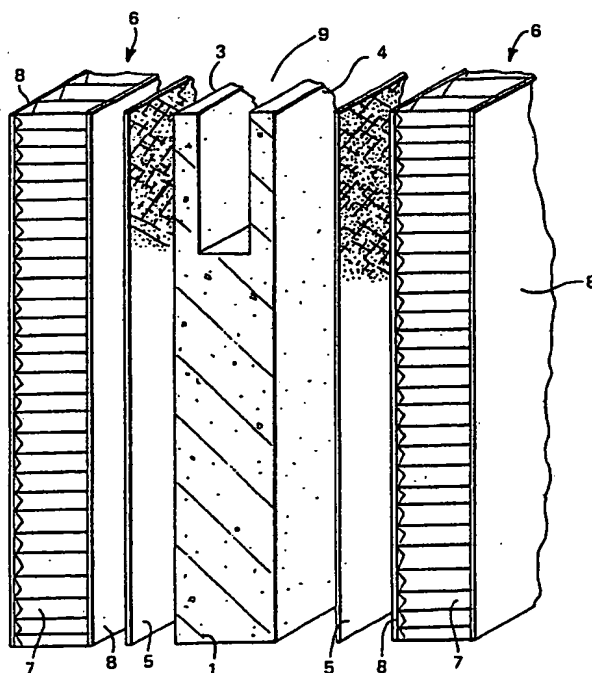


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(21) International Application Number: PCT/US90/07654 (22) International Filing Date: 28 December 1990 (28.12.90) (30) Priority data: 4211/89 29 December 1989 (29.12.89) IE (71) Applicant (for all designated States except US): STONE PANELS INTERNATIONAL LIMITED [IE/IE]; Main Street, Clifden, County Galway (IE). (72) Inventors; and (75) Inventors/Applicants (for US only) : PITTMAN, Eddie, Dar- nell [US/US]; 2810 Quail Ridge, Carrollton, TX 75006 (US). MITCHELL, John, Joseph [IE/IE]; Calla, Round- stone, County Galway (IE). (74) Agents: PATCH, Robert, J. et al.; Young & Thompson, 745 South 23rd Street, Arlington, VA 22202 (US).		(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GR (Euro- pean patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US. Published <i>With international search report.</i>

(54) Title: METHODS FOR MANUFACTURING COMPOSITE SURFACE ELEMENTS**(57) Abstract**

A method of manufacturing a stone-faced composite surface element in which a resin-impregnated fibrous matting (5) is applied to each of the two opposite faces of a stone slab (1) while the resin is in an uncured state. A backing layer (6) is applied to each of the exposed surfaces (3, 4) of the fibrous matting (5). The resin is cured to bond each backing layer (6) to the stone surface through the intermediary of the fibrous matting (5). The stone slab is sawn in two along a cutting plane (9) substantially parallel to, and midway between, the two opposed surfaces (3, 4) of the stone slab (1) to leave a thin lamina of stone attached to each backing layer. The backing layers (6) may be constructed in situ by applying to each exposed surfaces (3, 4) of the fibrous matting (5), after they have been attached to the stone slab (1), a layer of a light weight multicellular material (7), and then applying to the outer surface of the multicellular layer an outer skin of material (8).



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METHODS FOR MANUFACTURING COMPOSITE SURFACE ELEMENTS**5 TECHNICAL FIELD**

This invention concerns composite surface elements, such as panels, tiles and the like, having a natural stone facing, and a method for their construction. Such elements are intended for use, for example,
10 in the cladding of walls, ceilings or other surface, in the manufacture of furniture, and for all purposes where natural stone surfaces are required.

BACKGROUND ART

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Natural stone, such as marble, is an exquisite surfacing material on account of its hardness and durability, its beauty of structure and the high polish which can usually be imparted to it, but its use is greatly restricted by reason of its weight and expense, since the
20 material is liable to fracture if not of a certain thickness, depending on the handling and usage to which it may require to be subjected. These drawbacks are overcome by the invention the subject of U.S. Patent No. 3,723,233 which describes a method of preparing a stone-faced composite surface element having a lamina of stone bonded
25 to a backing sheet, comprising adhesively bonding to the surface of a stone slab a backing sheet of light-weight multicellular material of substantially greater thickness than said lamina, and thereafter sawing off a portion of said slab to leave a thin marble lamina adhered to the backing sheet of multicellular material. As the
30 backing sheet supports the lamina when it is being cut, the risk of cracking the lamina is reduced and remarkably thin stone laminae of the order of between 2 and 5 mm in thickness may be obtained.

In carrying out the aforesaid method a large block of stone is first
35 cut into a number of slabs which are of the order of 20 to 25 mm in

thickness. The slabs are dried and a lightweight backing sheet is bonded to each of the two opposite faces of the slab. The slab is then sawn in two along a cutting plane substantially parallel to and midway between said faces to leave a thin lamina of stone attached to each backing sheet.

It is disclosed in U.S. Patent No. 4,350,552 that the backing is a composite backing preferably comprising a light-weight core material, e.g. a multicellular metal core, which has a skin of sheet material of greater tensile strength than the core bonded to at least that surface of the core remote from the surface to which the stone lamina is attached. Preferably, both surfaces of the core are reinforced with a skin of sheet material.

In carrying out the prior method, the pre-formed composite backing is bonded to the surface of the stone slab by means of a resin. However, because the two surfaces to be bonded, that is the surface of the stone and the surface of the backing, are both rigid and because surface irregularities may occur on either or both surfaces, there is a tendency with the known method for air pockets to form between the backing and the stone slab. There is a danger that these air pocket might weaken the bond between the two components. Further, where air pockets exist there is a tendency for the stone lamina to crack or break at the weakened bond.

DISCLOSURE OF INVENTION

It is one object of the present invention to provide an improved method in which the aforesaid air pockets are eliminated.

It is another object of the present invention to provide an improved method in which the composite backing is not pre-fabricated but is assembled in situ.

Accordingly, the invention provides a method of manufacturing a stone-faced composite surface element comprising the following steps:

(1) applying to at least one surface of a stone slab a

resin-impregnated fibrous matting while the resin is in an uncured state,

5 (2) applying to the exposed surface of the fibrous matting a backing layer,

(3) curing the resin to bond the backing layer to the stone surface through the intermediary of the fibrous matting, and

10 (4) sawing off a portion of the stone slab to leave a thin lamina of stone adhered to the backing.

The backing may comprise a pre-fabricated composite backing comprising a multicellular core material to each surface of which has been bonded
15 a skin of sheet material of greater tensile strength than the core material.

In a preferred embodiment the resin-impregnated fibrous matting is applied to each of the two opposite faces of a stone slab while the
20 resin is in an unhardened and uncured state, a backing sheet of light-weight multicellular material is then bonded to each of the two opposite faces of the slab, through the intermediary of the respective matting, the slab is then sawn in two along a cutting plane substantially parallel to and midway between said faces to leave a
25 thin lamina of stone attached to each backing sheet.

In the methods described above, the backing sheet, comprising a multicellular core material sandwiched between two outer skins, is pre-fabricated before attachment to the stone slab. In accordance
30 with a further aspect of the present invention the backing is constructed in situ, and the invention provides a method of manufacturing a composite surface element having a lamina of stone bonded to a backing layer comprising the steps of:

35 (1) Applying to at least one of the opposed faces of a stone slab a sheet of resin-impregnated fibrous matting while the resin is in an unhardened and uncured state,

- 2) before the resin is fully cured, applying to the matting a core comprising a layer of light-weight material, and
- 5 (3) attaching an outer skin material to the opposite surface of the core,
- (4) allowing the resin to cure, and thereafter
- 10 (5) sawing a portion of the stone slab to leave a thin layer of stone adhered to the composite backing.

15 Preferably, the outer skin is also comprised of a fibrous matting material which is impregnated with a suitable resin. It is also preferred that instead of adhering the various elements of the backing to just one surface of the stone panel, a backing is bonded to each of the two opposite faces of the stone slab. The slab is then sawn in two along a cutting plane substantially parallel to and mid-way between the faces to leave a thin lamina of stone adhering to each backing.

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Some embodiments of the invention are hereinafter described with reference to the accompanying drawings wherein:

25 BRIEF DESCRIPTION OF DRAWINGS

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Figure 1 illustrates, to an enlarged scale, the various elements in the construction of a composite surface element according to the invention in accordance with a first embodiment of the invention; and

- 30 Figure 2 illustrates the various elements in the construction of a composite surface element in accordance with a second embodiment of the invention.

MODES FOR CARRYING OUT THE INVENTION

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In carrying out the methods of the invention, a block of stone, which may be marble, granite, onyx, limestone, slate or other stone, is cut into a number of slabs each of which has a thickness greater than

twice the thickness of the desired stone lamina of the composite surface element to be produced. The stone slabs, which may be rectangular in shape, are dried, either by leaving them for a period in racks to dry naturally, or by means of forced drying.

5

Referring now to Figure 1 of the drawings a dried stone panel 1 is prepared having two opposed surfaces 3,4. To each of the opposed surfaces 3,4 a resin-impregnated fibrous matting 5 is applied in the wet state, that is while the resin is still in an un-cured and unhardened state.

10

Suitably, the fibrous matting 5 may comprise an open-weave glass fibre matting or a carbon fibre matting. However, other forms of suitable matting or scrim may be used. The matting suitably has a thickness in the range between 0.1 mm and 2.0 mm. For example, matting of a thickness of 0.3 mm has been found to be suitable. The matting is impregnated with a suitable resin preferably an epoxy resin although other forms of resin may be used, for example, polyester resins, phenolic resins, and non-toxic (smokeless) resins.

15

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As mentioned above the resin-impregnated matting 5 is applied to each of the surfaces 3,4 of the stone slab 1. Before the resin sets or hardens, a pre-fabricated backing layer 6 is applied to the exposed surface of the matting. This can most easily be done by first laying flat a pre-fabricated backing layer 6. A sheet of wet resin-impregnated matting 5 is then laid flat on the upper surface of the backing layer 6. The stone slab 1 is then laid flat on top of the wet matting 5. A further sheet of wet resin-impregnated matting is then laid on the top surface of the stone, and finally a further pre-fabricated backing layer is laid flat on top of this. The layers are pressed firmly together to form a sandwich.

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It should be mentioned that it is not strictly necessary that the matting 5 must be wet when applied, providing that it is not fully cured. In the case of resins it is sufficient if the matting is applied while the resin is in a semi-cured state.

35

The pre-fabricated backing layer 6 may comprise a core 7 of a

lightweight material. Suitably, the core 7 is of a honeycomb or multicellular material. Preferably, the core 7 is a multicellular metal core made, for example, from aluminium. Alternatively, the core 7 may be made from a lightweight plastics material or from a resin-impregnated paper material. The cell walls of the multicellular core are arranged perpendicular to the plane of the sheet. The cells are closed on both surfaces of the core by a skin 8 of a relatively thin sheet of a tough material having good tensile qualities. The skin 8 may comprise, for example, a resin-impregnated glass fibre matting, sheet metal such as aluminium, or a tempered hardboard. The sheets 8 are firmly bonded to the core to form a lightweight backing.

At this stage in the process, the slab 4, with the attached mattings 5 and backing sheets 6, are placed on a vacuum table or into a vacuum chamber. Vacuum is then applied to remove any air residing between the various layers of the composite structure. The vacuum causes entrapped air to travel along the fibre strands in the matting material from the centre of the panel to the outside.

The resin is then allowed to cure and harden so that all of the components of the composite structure are firmly bonded together.

The slab 4 is then sawn in two along a cutting plane 9 substantially parallel to and between the faces 3,4 of the slab leaving a thin lamina of stone attached to each of the backing sheets 6. For example, if the original slab is 20 mm in thickness, a kerf of about 12 mm is lost in the cutting process, to leave a lamina of stone of about 4 mm in thickness adhering to each backing. Apparatus such as that described in U.S. Patent No. 4,350,552 may be used in the cutting process.

Referring now to Figure 2 of the drawings, this illustrates a further embodiment of the method of the invention. In the method as described in relation to Figure 1, the lightweight backing sheet 6 was prefabricated before bonding to the stone slab 1. In this embodiment the backing 6 is assembled in situ, which has the advantage that a vacuum-treating step as referred to in relation to Figure 1 is not required.

In the arrangement shown in Figure 2, a resin-impregnated fibrous matting 5 is applied to each of the opposed surfaces 3,4 of the stone slab as described in Figure 1. While the resin is still in an uncured state, a sheet 7 of a multicellular material of the kind described above, is pressed onto the exposed surface of the fibrous matting 5. A second sheet 8 of resin-impregnated fibrous matting is applied, also in the wet state, to the outer surface of the multicellular sheet material.

10 All of the sheets of the composite structure are then pressed together and the resin is allowed to cure under conditions of elevated temperature to achieve a firm and strong bond between each of the sheet elements.

15 Thereafter, the stone slab 1 is sawn in two as described above in relation to Figure 1.

In the method as illustrated in the drawings, the fibrous matting 4 and backing 6 are applied to the two opposite faces of the slab 7, and the slab 1 is then cut in two. However, it will be appreciated that it is also possible to apply the fibrous matting 4 and the backing 6 to a single surface of a slab or block of stone, and thereafter saw off a portion of the stone to leave a thin lamina of stone adhered to the backing.

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CLAIMS

1. A method of manufacturing a stone-faced composite surface element comprising the following steps:

- 5 (1) Applying to at least one surface of a stone slab a resin-impregnated fibrous matting while the resin is in an uncured state,
- 10 (2) applying to the exposed surface of the fibrous matting a backing layer,
- (3) curing the resin to bond the backing layer to the stone surface through the intermediary of the fibrous matting, and
- 15 (4) sawing off a portion of the stone slab to leave a thin lamina of stone adhered to the backing.

2. A method as claimed in Claim 1, wherein the resin-impregnated fibrous matting is applied to each of the two opposite faces of the stone slab, a backing layer is attached to each of said two opposite faces of the stone slab through the intermediary of the respective fibrous matting, and after curing of the resin the slab is sawn in two along a cutting plane substantially parallel to and midway between said faces to leave a thin lamina of stone attached to each backing layer.

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3. A method as claimed in Claim 1 or Claim 2, wherein the backing layer is a pre-fabricated backing sheet comprising a lightweight multicellular core sandwiched between two outer skins.

30

4. A method as claimed in Claim 1 or Claim 2, wherein the backing layer is formed in situ by firstly applying to the exposed surface of the resin-impregnated fibrous matting a layer of a lightweight multicellular material, then applying to the outer surface of the multicellular layer an outer skin of material.

35

5. A method as claimed in Claim 1 or Claim 2, wherein the stone panel, fibrous matting, and backing layer are pressed together while

the resin is in an uncured state, vacuum is applied to the composite structure to remove air trapped between layers of the composite structure, and thereafter the resin is cured.

5 6. A method of manufacturing a composite surface element having a lamina of stone bonded to a backing layer comprising the following steps:

10 (1) applying to at least one of the opposed faces of a stone slab a sheet of resin-impregnated fibrous matting while the resin is in an uncured state,

(2) before the resin is cured, applying to the fibrous matting a core comprising a layer of light-weight material, and

15 (3) attaching an outer skin of material to the opposite surface of the core,

(4) allowing the resin to cure, and thereafter

20 (5) sawing a portion of the stone slab to leave a thin layer of stone adhered to the composite backing.

25 7. A method as claimed in Claim 5, wherein the sheet of resin-impregnated fibrous matting, the core, and outer skin are applied to each of the two opposed faces of a stone slab, and, after the resin has cured, the slab is sawn in two along a cutting plane substantially parallel to and midway between said opposed faces to leave a thin lamina of stone attached to each composite backing layer.

30 8. A method as claimed in any of the preceding Claims wherein the fibrous matting is an open-weave glass fibre matting.

35 9. A method as claimed in any of the preceding Claims wherein the resin is an epoxy resin.

10. A stone-faced composite surface element whenever manufactured by a method as claimed in Claim 1 or Claim 6.

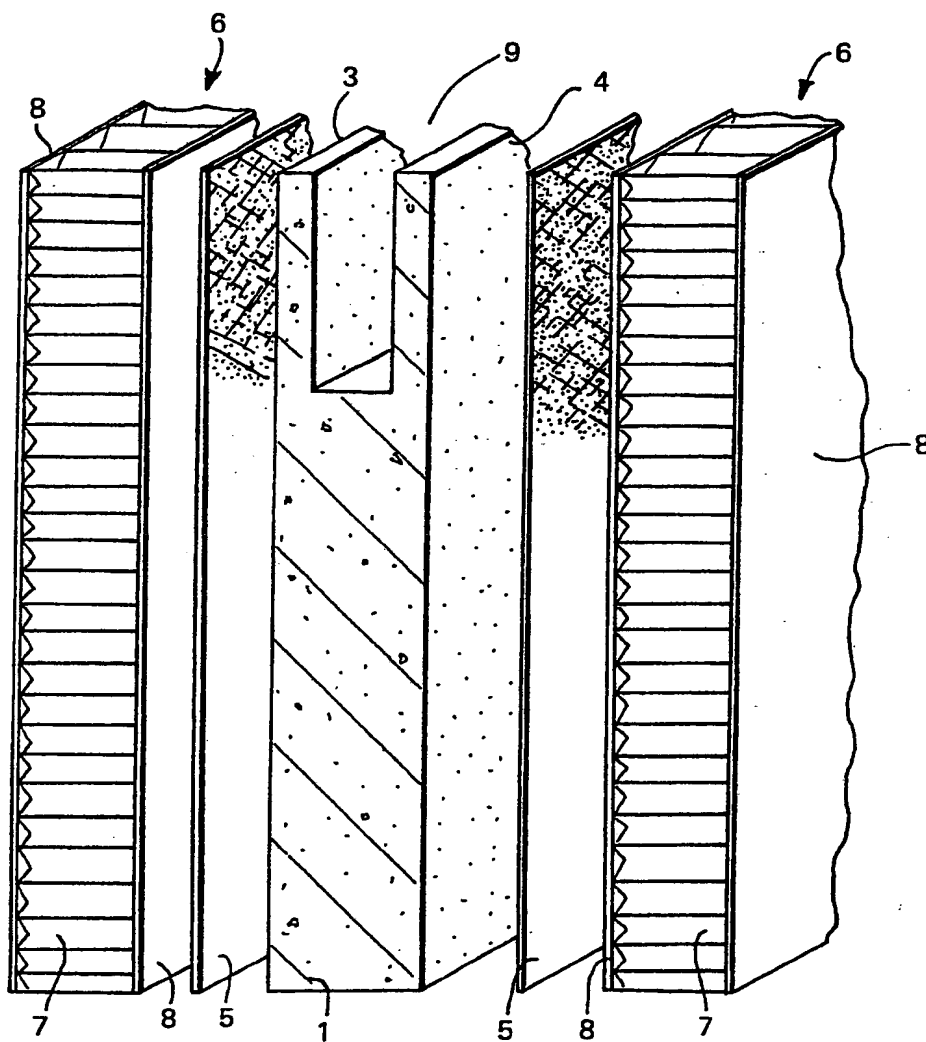


FIG. 1

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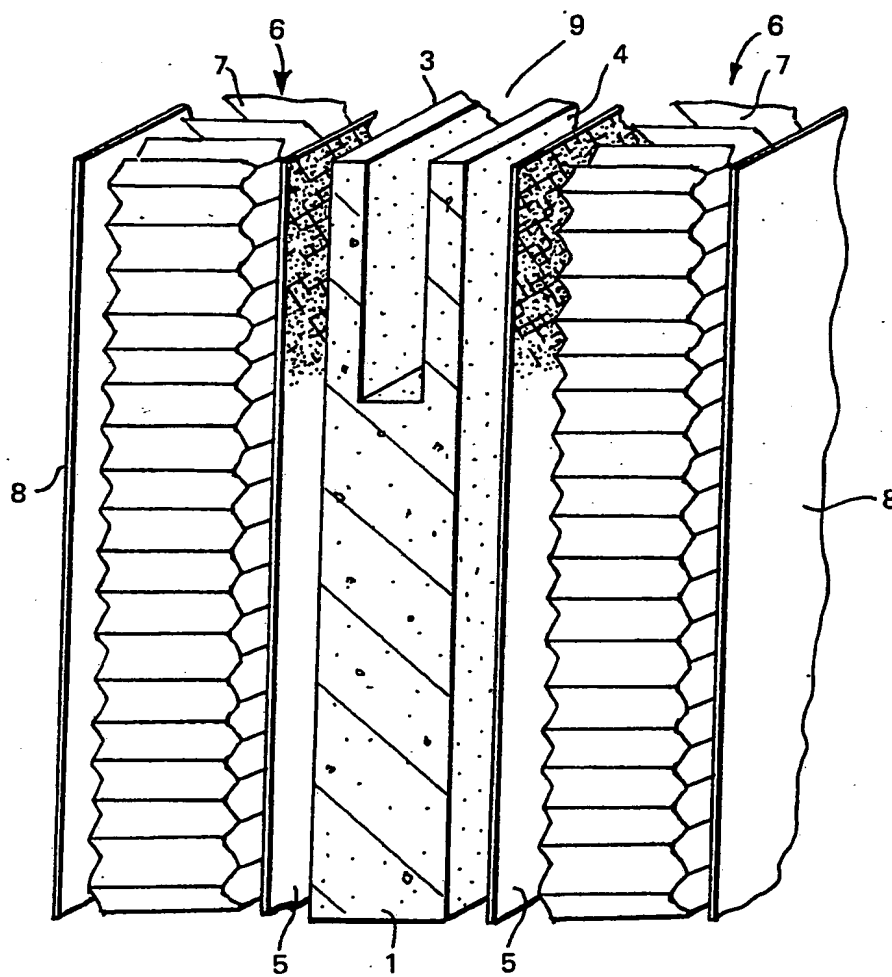


FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No. Pct/US90/07654

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC (5): B32B 31/00 U.S. Cl. 156/254; 125/13.01																				
II. FIELDS SEARCHED <div style="text-align: center; font-size: small;">Minimum Documentation Searched ⁷</div> <table style="width: 100%; border: none;"> <tr> <td style="width: 25%; border: none; vertical-align: top;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> Classification System U.S. </div> </td> <td style="border: none; vertical-align: top;"> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> Classification Symbols 83/36; 125/12, 13.01; 156/254, 267 </div> </td> </tr> </table> <div style="border: 1px solid black; padding: 5px; font-size: x-small;"> Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸ </div>			<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> Classification System U.S. </div>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> Classification Symbols 83/36; 125/12, 13.01; 156/254, 267 </div>																
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III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹ <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%; font-size: x-small;">Category ¹¹</th> <th style="width: 70%; font-size: x-small;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 20%; font-size: x-small;">Relevant to Claim No. ¹³</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Y</td> <td>US, A, 3,723,233 (BOURKE) 19 February 1968 See entire document</td> <td style="text-align: center;">1-10</td> </tr> <tr> <td style="text-align: center;">Y</td> <td>US, A, 4,350,552 (BOURKE) 21 September 1982 See entire document</td> <td style="text-align: center;">1-10</td> </tr> <tr> <td style="text-align: center;">Y</td> <td>US, A, 4,436,078 (BOURKE) 13 March 1984 See entire document</td> <td style="text-align: center;">1-10</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US, A, 4,822,661 (BATTAGLIA) 18 April 1989 See entire document</td> <td style="text-align: center;">1,6</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US, A, 3,978,263 (WELLENSTIEK) 31 August 1976 See entire document</td> <td style="text-align: center;">1,6</td> </tr> </tbody> </table>			Category ¹¹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	Y	US, A, 3,723,233 (BOURKE) 19 February 1968 See entire document	1-10	Y	US, A, 4,350,552 (BOURKE) 21 September 1982 See entire document	1-10	Y	US, A, 4,436,078 (BOURKE) 13 March 1984 See entire document	1-10	A	US, A, 4,822,661 (BATTAGLIA) 18 April 1989 See entire document	1,6	A	US, A, 3,978,263 (WELLENSTIEK) 31 August 1976 See entire document	1,6
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Δ" document member of the same patent family</p> </div> </div>																				
IV. CERTIFICATION <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> Date of the Actual Completion of the International Search <div style="border: 1px solid black; padding: 5px; text-align: center;">03 APRIL 1991</div> </td> <td style="width: 50%; border: none; vertical-align: top;"> Date of Mailing of this International Search Report <div style="border: 1px solid black; padding: 5px; text-align: center;">12 APR 1991</div> </td> </tr> <tr> <td style="border: none; vertical-align: top;"> International Searching Authority ISA/US </td> <td style="border: none; vertical-align: top;"> Signature of Authorized Officer <i>Nguyen Ngoc Ho</i> For JIM ENGEL NGUYEN NGOC-HO INTERNATIONAL DIVISION </td> </tr> </table>			Date of the Actual Completion of the International Search <div style="border: 1px solid black; padding: 5px; text-align: center;">03 APRIL 1991</div>	Date of Mailing of this International Search Report <div style="border: 1px solid black; padding: 5px; text-align: center;">12 APR 1991</div>	International Searching Authority ISA/US	Signature of Authorized Officer <i>Nguyen Ngoc Ho</i> For JIM ENGEL NGUYEN NGOC-HO INTERNATIONAL DIVISION														
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